Electronics/Computers

Wavefront Correction for Large, Flexible Antenna Reflector

NASA's Jet Propulsion Laboratory, Pasadena, California

A wavefront-correction system has been proposed as part of an outer-space radio communication system that would include a large, somewhat flexible main reflector antenna, a smaller subreflector antenna, and a small array feed at the focal plane of these two reflector antennas. Part of the wavefront-correction system would reside in the subreflector, which would be a planar patch-element reflectarray antenna in which the phase shifts of the patch antenna elements would be controlled via microelectromechanical systems (MEMS) radio-frequency (RF) switches. The system would include the following sensing-and-computing subsystems:

- An optical photogrammetric subsystem built around two cameras would estimate geometric distortions of the main reflector;
- A second subsystem would estimate wavefront distortions from amplitudes and phases of signals received by the array feed elements; and
- A third subsystem, built around small probes on the subreflector plane, would estimate wavefront distortions from differences among phases of signals received by the probes.

The distortion estimates from the three subsystems would be processed to generate control signals to be fed to the MEMS RF switches to correct for the distortions, thereby enabling collimation and aiming of the received or transmitted radio beam to the required precision.

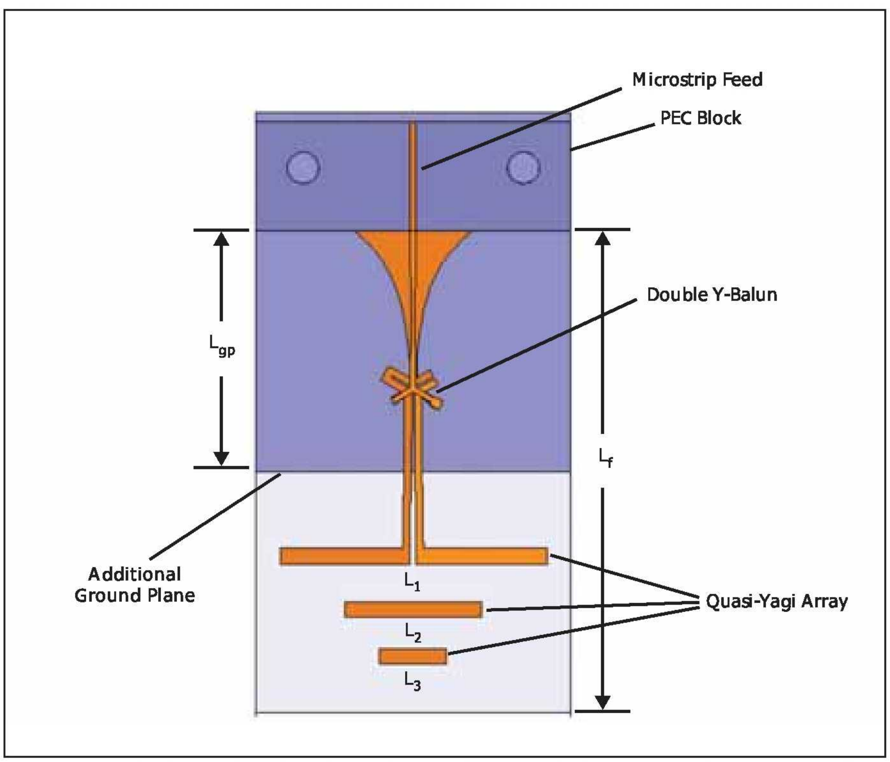
This work was done by William A. Imbriale and Vahraz Jamnejad of Caltech and Yahya Rahmat-Samii, Harish Rajagopalan, and Shenheng Xu of the University of California, Los Angeles, for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46053

Novel Microstrip-to-Waveguide Feed Employing a Double-Y Junction

This feed is useful for low-cost measurements involving waveguides up to X-band.

NASA's Jet Propulsion Laboratory, Pasadena, California

Previous microstrip-to-waveguide transitions either required a hermetically sealed waveguide configuration, or a balun that needed to be tuned according to the frequency band of interest. In this design, the balun is realized using a double-Y junction to transition from microstrip to coplanar strip feeding a quasi-Yagi dipole array (see figure). The length of the feed (L_f) extending into the waveguide is 15.54 mm. The length of the ground plane below the ULTRALAM substrate is 7.75 mm. The lengths L_1, L_2, and L_3 are 8.50 mm, 4.38 mm, and 2.14 mm, respectively. These lengths were computed via a preliminary optimization aimed at improving the return loss at the band edges.



The **Microstrip-to-Waveguide (WR-90) Transition** employing double-Y balun and modeled in HFSS.

The waveguide feed was designed to excite the TE10 mode in a WR-90 waveguide, and to operate over the recommended frequencies of 8.2 to 12.4 GHz. The feed employs a Rogers 6010 substrate (dielectric constant $\varepsilon_r \approx 10.2$) bonded with a Rogers ULTRALAM substrate ($\varepsilon_r \approx 2.5$). The ULTRALAM substrate serves to provide mechanical strength for 6010 substrate, and to mitigate loses due to parasitic modes (the ground plane is etched on the bottom of this layer due to the topology of the double-Y balun).

The double-Y balun transitioning from an unbalanced microstrip line to a balanced coplanar strip (CPS) line does not provide inherent impedance transformation; hence, Klopfenstein impedance tapers were synthesized to transition from 50 to 77 Ω in the microstrip section and from 77 to 110 Ω in the CPS section. At the balun junction, the CPS stub lengths were chosen such that the λ/8 resonance is pushed outside the bandwidth of operation. Also, the smallest allowable conductor width and gap spacing were chosen to meet acceptable manufacturing tolerances.

The microstrip-to-waveguide transition has been analyzed numerically using a commercial 3D finite-element electromagnetic solver. The WR-90 waveguide (10.16×22.86×25.56 mm) was modeled as an air box. The 6010 and ULTRALAM substrates were modeled to account for dielectric losses. The microstrip section of the waveguide feed was excited using a 50-Ω lumped port; the output face of the waveguide was modeled as a wave port. The waveguide achieves maximum insertion loss of 0.84 dB, and a minimum insertion loss of 0.32 dB from 8.0 to 12.4 GHz with the ULTRALAM substrate and additional ground. The resulting insertion loss at the band edges is significantly lower. Further improvement in the insertion loss of the waveguide feed can potentially be obtained with continued numerical optimization.

This work was done by Jaikrishna Venkatesan of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). ***NPO-42667***

Thin-Film Ferroelectric-Coupled Microstripline Phase Shifters With Reduced Device Hysteresis

These are useful for electronically steerable ferroelectric reflectarray antennas.

John H. Glenn Research Center, Cleveland, Ohio

This work deals with the performance of coupled microstripline phase shifters (CMPS) fabricated using $Ba_xSr_{1-x}TiO_3$ (BST) ferroelectric thin films. The CMPS were fabricated using commercially available pulsed laser deposition BST films with Ba:Sr ratios of 30:70 and 20:80. Microwave characterization of these CMPS was performed at upper Ku-band frequencies, particularly at frequencies near 16 and 18 GHz. X-ray diffraction studies indicate that the 30:70 films exhibit almost a 1:1 ratio between the in-plane and out-of-plane lattice parameters, suggesting that their cubics create strain-free films suitable for producing CMPS devices with reduced hysteresis in the paraelectric state.

The quality of performance of the CMPS was studied based on their relative phase shift ($\Delta\phi = \phi_{nV} - \phi_{0V}$, where $n = 0$ to 400 volts DC) and insertion loss within the DC bias range of 0 to 400 V (i.e., E-field ranges within 0 to 53 V/μm). The performance of the CMPS was tested as a function of temperature to investigate their operation in the paraelectric, as well as in the ferroelectric, state (i.e., above and below the Curie temperature, respectively). The novel behavior discussed here is based on the experimental observation of the CMPS. Remarkably, these devices were hysteresis-free in the paraelectric state, and only showed $\Delta\phi$ hysteresis while performing in the ferroelectric state. This behavior, observed for the aforementioned cation ratio, highlights the relevance of good crystalline structure for high-quality CMPS.

Elimination of $\Delta\phi$ hysteresis is essential for practical microwave applications such as voltage-controlled oscillators and beam-steerable devices, particularly electronically steerable phased array antennas, which require accurate phase shift versus tuning voltage profiles for reliable operation. Accordingly, the optimization of the interplay among film microstructure, Ba content, and dielectric constant is critical for reliable CMPS devices. The origin of hysteresis is most likely related to fixed charges and ferroelectric domain phenomena in the ferroelectric state, as well as remnant ferroelectric domains in the paraelectric state. Consequently, to achieve minimum device hysteresis in the paraelectric domain, the BST films selected for the CMPS devices should be of optimal film composition [i.e., FWHM (full width at half maximum) < 0.05°], with minimum film strain (i.e., in-plane to out-of-plane lattice parameters ratio as close as possible to 1), and moderate values of dielectric constant (≈800 at $V = 0$) to enable acceptable tunability at manageable insertion losses.

This work was done by Félix A. Miranda and Robert Romanofsky of Glenn Research Center, Carl H. Mueller of Qinetiq North America, and Frederick Van Keuls of Ohio Aerospace Institute. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18370-1.

Two-Stage, 90-GHz, Low-Noise Amplifier

NASA's Jet Propulsion Laboratory, Pasadena, California

A device has been developed for coherent detection of the polarization of the cosmic microwave background (CMB). A two-stage amplifier has been designed that covers 75–110 GHz. The device uses the emerging 35-nm InP HEMT technology recently developed at Northrop Grumman Corporation primarily for use at higher frequencies. The amplifier has more than 18 dB gain and less than 35 K noise figure across the band.

These devices have noise less than 30 K at 100 GHz. The development started with design activities at JPL, as well as